I: Superpave: The Future of Asphalt

COURSE OBJECTIVES

Superpave is an acronym for Superior Performing Asphalt Pavements.   Superpave is a new, comprehensive asphalt mix design and analysis system, a product of the Strategic Highway Research Program. Congress established SHRP in 1987 as a five-year, $150 million research program to improve the performance and durability of United States roads and to make those roads safer for both motorists and highway workers. $50 million of the SHRP research funds were used for the development of performance based asphalt material specifications to relate laboratory analysis with field performance.

Since the completion of the SHRP research in 1993, the asphalt industry and most highway agencies have been focusing great effort in implementing the Superpave system in their highway design and construction practices. Much of the implementation effort has involved training personnel in the proper use of Superpave technology, from introductory courses on how Superpave works to detailed laboratory courses for providing hands-on instruction with the new Superpave materials testing equipment.

This course is another step toward informing highway industry personnel of the benefits of Superpave. The intended audience for this course are those involved in the design and construction of hot mix asphalt pavements, including contractors, agency personnel, and consulting engineers. The primary goals of this course are to describe the Superpave components, the critical requirements, why they are needed, and how this new system could impact the production and construction procedures for hot mix asphalt.

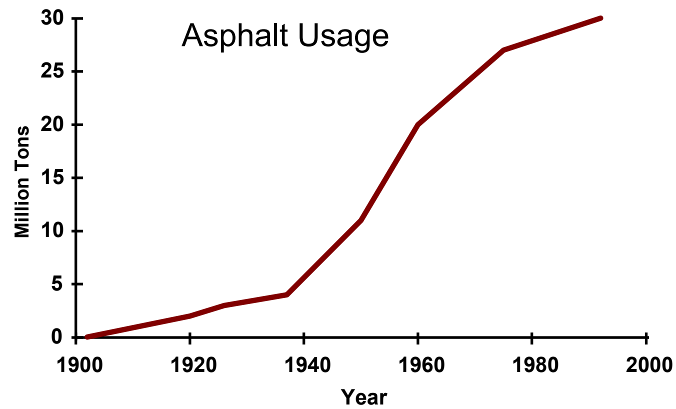
This course begins with an introduction to the origins of the research that produced Superpave. Then the ways in which Superpave can improve pavement performance are investigated, including a review of the behavior of hot mix asphalt materials. An overview of the Superpave material tests is next, followed by a discussion of how asphalt and aggregate materials are selected in a Superpave mix design. Asphalt mixture volumetrics remain a primary element of the Superpave mix design system, and a review of basic volumetric principles precedes a detailed example describing the major steps of a Superpave mix design. After the design example, there is a discussion of the possible handling differences that Superpave requirements could bring about during hot mix asphalt production, placement and compaction. The course concludes with a brief look at the Superpave mix analysis procedures that continue to evolve, and an update of the ongoing activities involved with implementing the Superpave system.

To benefit as much as possible from this course, participants are encouraged to ask questions and share experience, especially those related to their job activities. In order to have a comprehensive reference when you leave, you are encouraged to take notes directly in this book.

WHY SUPERPAVE?

To fully understand the evolution of the Superpave system, it may help to review a bit of the history of the development of highways and the asphalt industry.

Since the development of the gas engine and the discovery of the petroleum asphalt refining process, asphalt has seen increasingly widespread use in pavement applications. From road oiling of local roads to heavy duty airfield applications, the versatility of asphalt materials has provided the pavement engineer with a valuable material resource.



The design of asphalt mixtures evolved with its increasing use. The Hubbard-Field method was originally developed in the 1920s for sheet asphalt mixtures with 100 percent passing the 4.75 mm sieve, and later modified to cover the design of coarser asphalt mixtures. The Hubbard-Field Stability test measured the strength of the asphalt mixture with a punching-type shear load.

Hveem Mix Design was developed by the California Department of Highways Materials and Design Engineer in the 1930s. The Hveem stabilometer measures an asphalt mixture's ability to resist lateral movement under a vertical load. Hveem mix design is still used in California and other western states.

Marshall mix design was originally developed by a Mississippi State Highway Department Engineer and later refined in the 1940s by the Corps of Engineers for designing asphalt mixtures for airfield pavements. The primary features of Marshall mix design are a density/voids analysis and the stability/flow test. Prior to Superpave, Marshall mix design was widely used in the United States, and is by far the most commonly used mix design procedure worldwide.

Refinements to the concepts of asphalt mix design procedures came about not only with the increasing use of asphalt, but also with the increasing demand placed on the mixtures by increases in traffic volume and loading. The authorization of the Interstate Highway System in 1956 set the cornerstone for the United States reliance on highway transportation for its primary mode of transporting goods and people.

The AASHO Road Test, conducted from 1958 to 1962, set the standard for pavement structural design, and the data that the Road Test produced is still the basis for the majority of pavement design procedures. The researchers were aware that the Road Test was limited to one set of soils and climatic conditions, and other studies were planned to extend their findings to other geographic areas. Generally, these studies were not conducted, and the AASHO Road Test results were extrapolated to fit other design conditions.

The growth of the Interstate system was matched by the increase in trucking as a mode for shipping goods -- vehicles-miles traveled increased 75 percent between 1973 and 1993. Provided with an infrastructure to transport the goods, the trucking industry pushed for increased productivity, and the legal load limit was raised from 73,280 to 80,000 lb. in 1982. This seemingly small increase actually increases the stress to the pavement 40 to 50 percent for a given structural design. The advent of more economical radial tires also increased the stress to the pavement.

As the transportation industry grew, the use of hot mix asphalt in heavy-duty pavement applications grew, and the results were not always favorable. Many theories were suggested to explain the reduction in performance of asphalt pavements: since the 1973 oil embargo, the oil companies have taken the "goodies" out of the asphalt to make more gasoline; the increased use of reclaimed asphalt pavement (RAP) has led to weaker mixtures; drum mixers don't make as good a mixture as batch plants.

Although none of these theories was found to have any basis, in truth the states were finding an increasingly fine line developing between mixtures that performed well and mixtures that performed poorly. The materials were the same, but the increases in traffic load and volume were pushing the need for a better understanding of asphalt materials and pavement performance.

STRATEGIC HIGHWAY RESEARCH PROGRAM

Against this background of declining performance and diminishing research funding, SHRP was approved by Congress in 1987 as a five year, $150 million research program to improve the performance and durability of United States roads and to make those roads safer for both motorists and highway workers. One third of the SHRP research funds were directed for the development of performance based asphalt material specifications to more closely relate laboratory measurements with field performance.

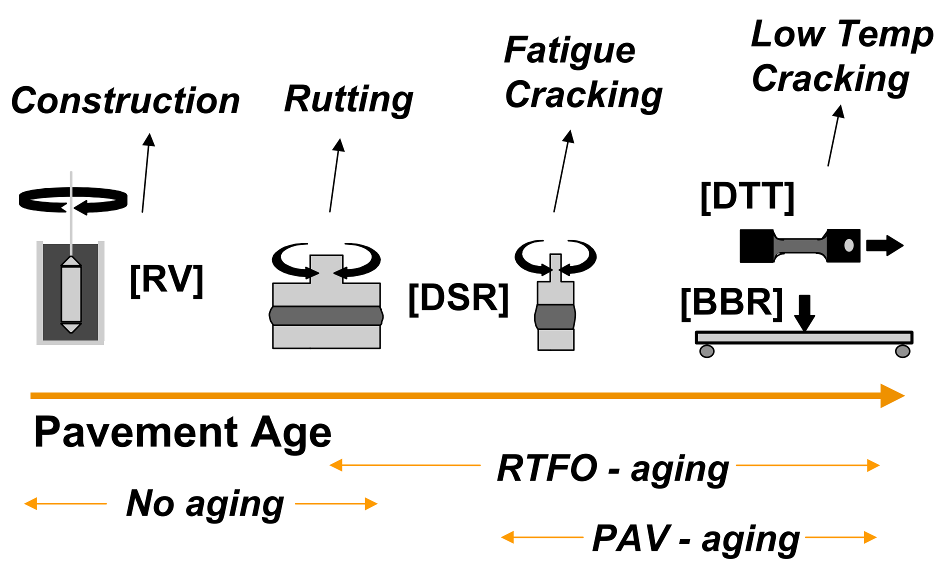
SHRP was originally proposed in Transportation Research Board Special Report No. 202, "America's Highways: Accelerating the Search for Innovation." This report outlined the need for a concentrated effort to produce major innovations for increasing the productivity of the nation's highways. Various problems in areas of highway performance and safety had been hampering the highway industry, and this report called for a renewed effort to solve these problems. However, this report did not just call for funding of research in these areas, but also emphasized the need for conducting the research with implementation in mind. A "program designed without taking into account obstacles on implementation of research will fail" noted the report, and this statement continues to guide the highway industry now that the SHRP research has been completed and its products are being evaluated and implemented.

The goal of the SHRP asphalt research was the development of a system that would relate the material characteristics of hot mix asphalt to pavement performance. Asphalt materials have typically been tested and designed with empirical laboratory procedures, meaning that field experience was still required to determine if the laboratory analysis implied good pavement performance. However, even with proper adherence to these procedures and the development of mix design criteria, asphalt technologists have had various degrees of success in overcoming the three main asphalt pavement distresses: permanent deformation or rutting; fatigue cracking, which leads to alligator cracking; and low temperature cracking.

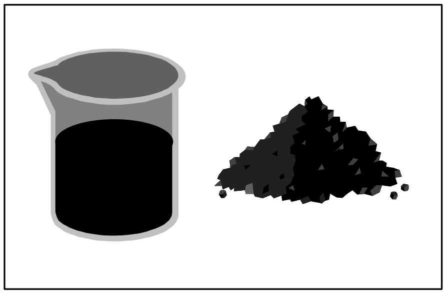
The opinions of what issues needed to be resolved by the SHRP asphalt research varied. Some industry personnel felt that a chemical based specification would provide the answer to developing a more "robust" asphalt cement to ensure better pavement performance in light of increased traffic and higher wheel loads. Other engineers believed that poor pavement performance was a combination of inadequate mix design procedures and poor construction practices, and that focusing solely on the asphalt cement would be unproductive. Consequently, SHRP researchers set out to develop a chemically based asphalt binder specification and investigate improved methods of mix design.

A final product of the SHRP asphalt research is the Superpave asphalt mixture design and analysis system. Superpave is an acronym for Superior Performing Asphalt Pavements. Superpave represents an improved, performance-based system for specifying asphalt binders and mineral aggregates, performing asphalt mixture design, and analyzing pavement performance. The system includes an asphalt binder specification that uses new binder physical property tests; a series of aggregate tests and specifications; a hot mix asphalt (HMA) design and analysis system; and computer software to integrate the system components. As with any design process, field control measurements are still necessary to ensure the field produced mixtures match the laboratory design. The Superpave binder specification and mix design procedures incorporate various test equipment, test methods, and design criteria.

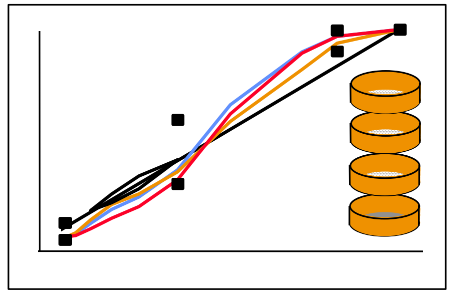
A unique feature of the Superpave system is that its tests are performed at temperatures and aging conditions that more realistically represent those encountered by in-service pavements. If the pavement distresses addressed by Superpave (rutting, fatigue cracking, and low temperature cracking) do occur in the pavement, they do so at relatively typical stages in a pavement's life and under relatively common temperature conditions. The Superpave performance graded (PG) binder specification makes use of these tendencies to test the asphalt under a project's expected climatic and aging conditions to help reduce pavement distress. SHRP researchers developed new equipment standards as well as incorporated equipment used by other industries to develop the binder tests.



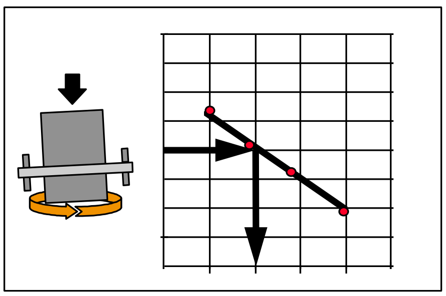
The Superpave mixture design and analysis system uses increasingly rigorous degrees of testing and analysis to provide a well performing mixture for a given pavement project. The Superpave mix design procedure involves careful material selection and volumetric proportioning as a first approach in producing a mix that will perform successfully. The four basic steps of Superpave asphalt mix design are materials selection, selection of the design aggregate structure, selection of the design asphalt binder content, and evaluation of the mixture for moisture sensitivity.



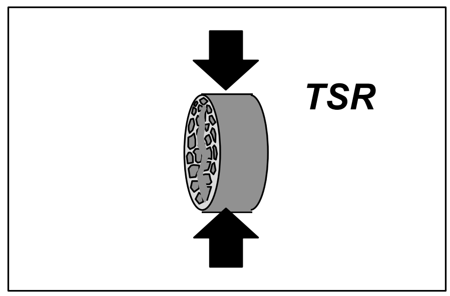
1. Materials Selection



2. Design Aggregate Structure



3. Design Binder Content



4. Moisture Sensitivity

4 Steps of Superpave Mix Design

Asphalt mixes in more critical, higher traffic volume projects can be optimized for the actual project conditions using an analysis to estimate pavement performance. The analysis procedures, still under development, will use increasingly sophisticated and comprehensive testing and modeling of the design asphalt mixture, as desired and necessary to predict performance for the actual pavement structure, climate, and traffic.

SUPERPAVE IMPLEMENTATION

How far along are the asphalt and highway industries toward routine use of Superpave? That question will be answered in detail in the final section of this course. At this point it is sufficient to note that the FHWA, the states and the asphalt industry are working together in the many on-going Superpave implementation and validation activities. Through AASHTO, the Superpave test methods and specifications are being standardized, which will further accelerate and facilitate the acceptance and use of this new and improved asphalt mix design and analysis system.